# Lab session 3

## Design of antennas in CST

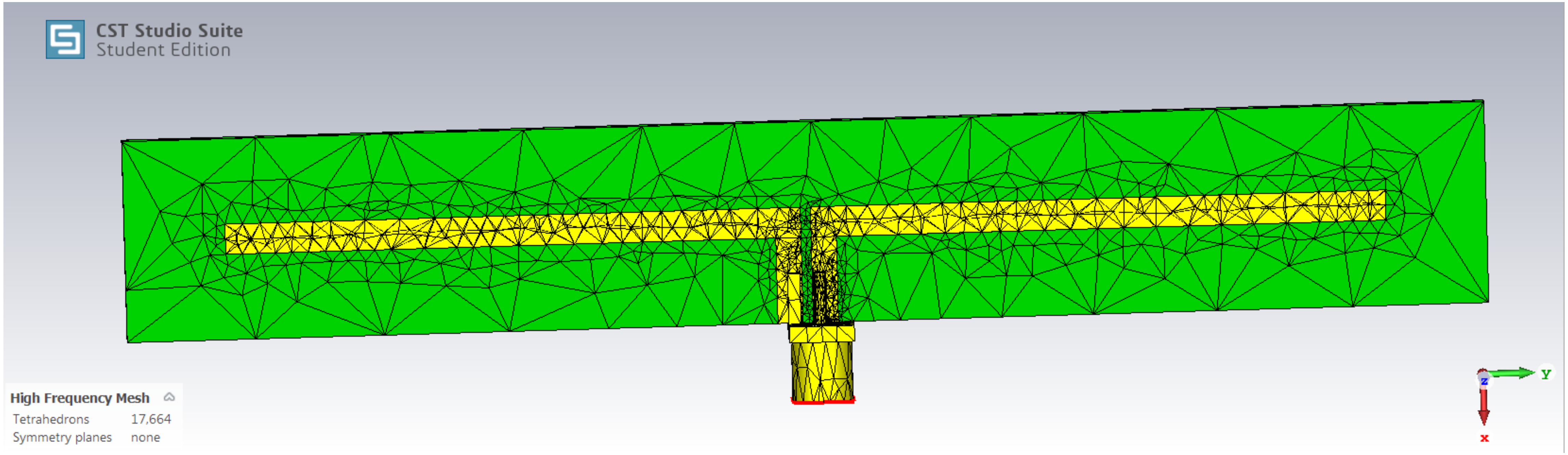
# Topics

- **How do antenna modeling tools work?**
- Relative permittivity
- CST
- Simulating your antenna

# What is an antenna?

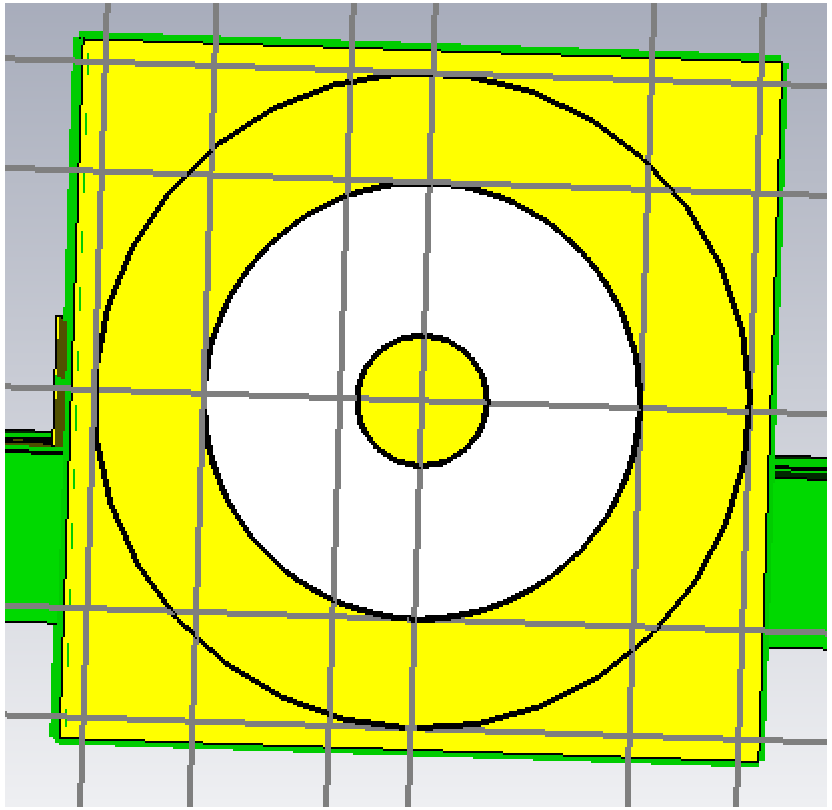
# How do antenna modeling tools work?

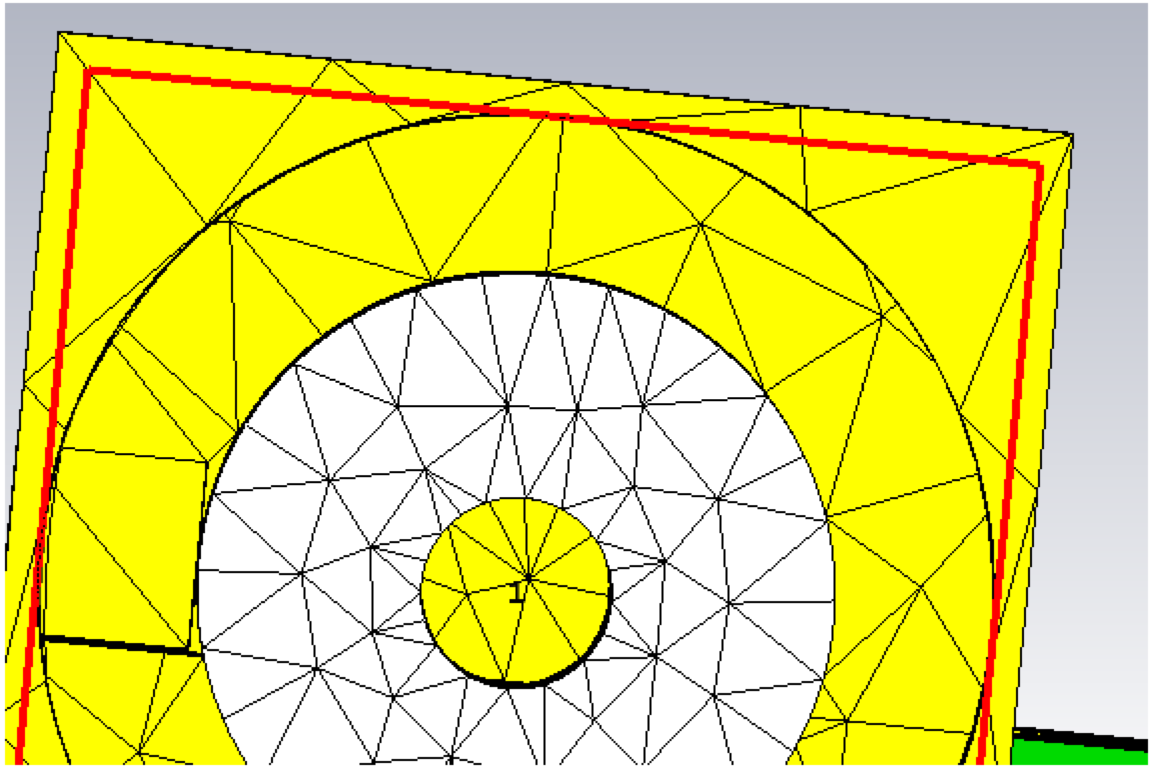
<u>Modeling merely provides an approximation of the truth!</u>



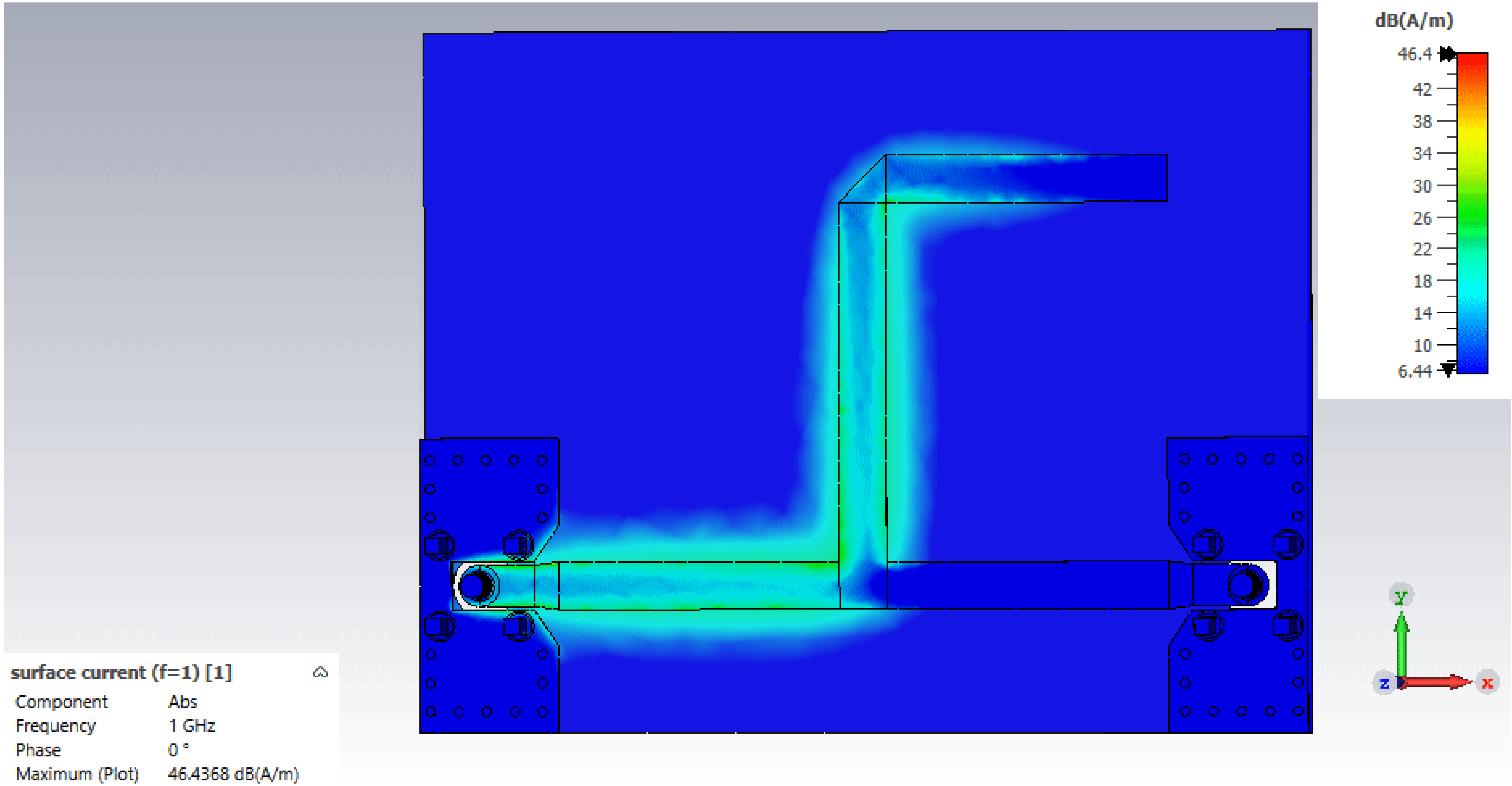
# How do antenna modeling tools work?

## Modeling merely provides an approximation of the truth!



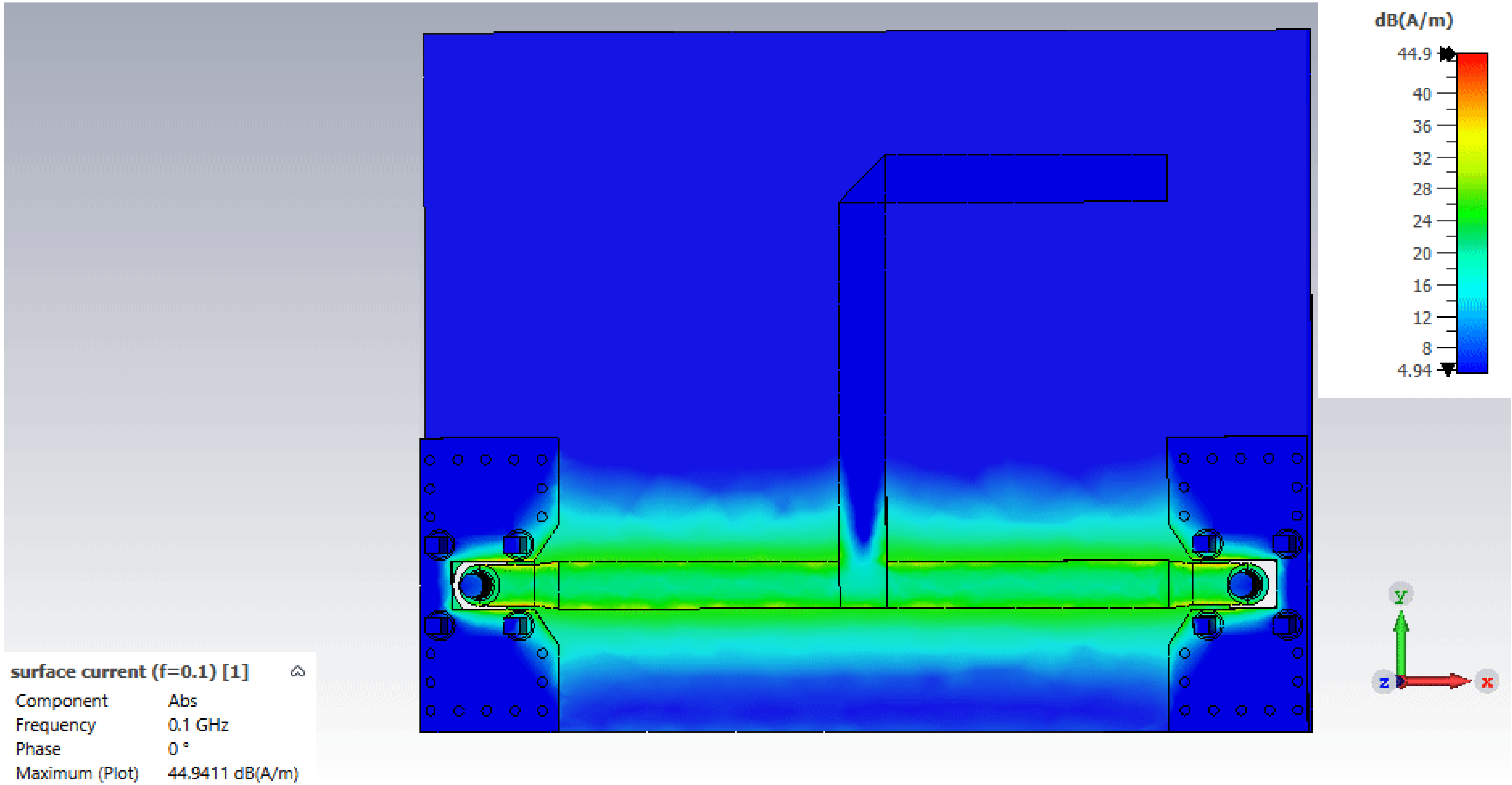


# How do antenna modeling tools work?



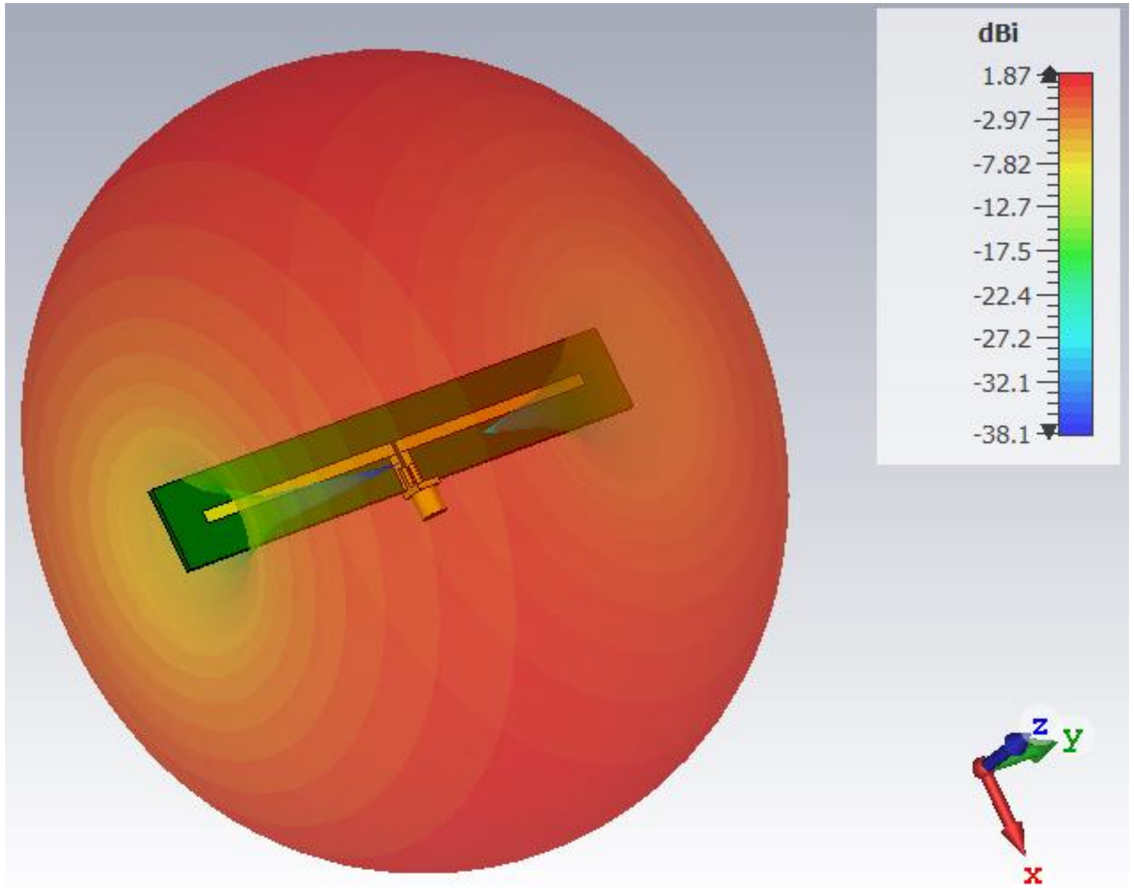

Open-ended stub @1 GHzc

# How do antenna modeling tools work?




Open-ended stub @0.1 GHzc

# How do antenna modeling tools work?

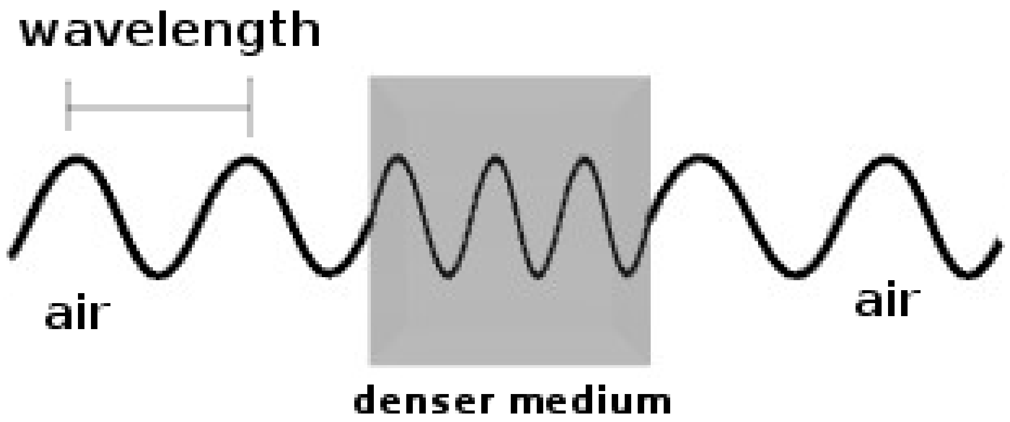


# Topics

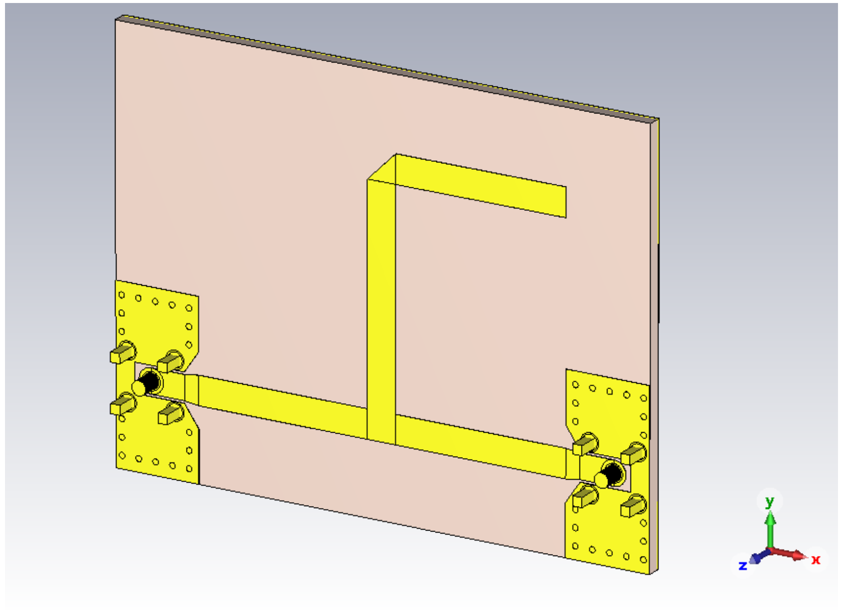
- How do antenna modeling tools work?
- **Relative permittivity**
- CST
- Simulating your antenna

# Relative permittivity

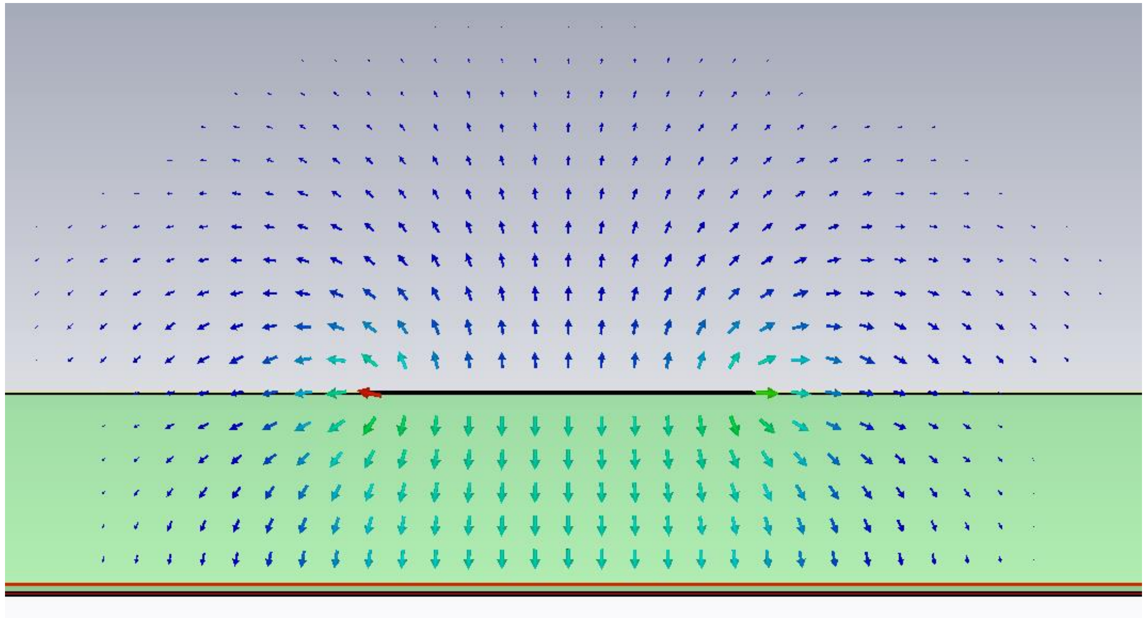
$$\lambda = \frac{c_0}{f\sqrt{\varepsilon_r}}$$



# Effective relative permittivity

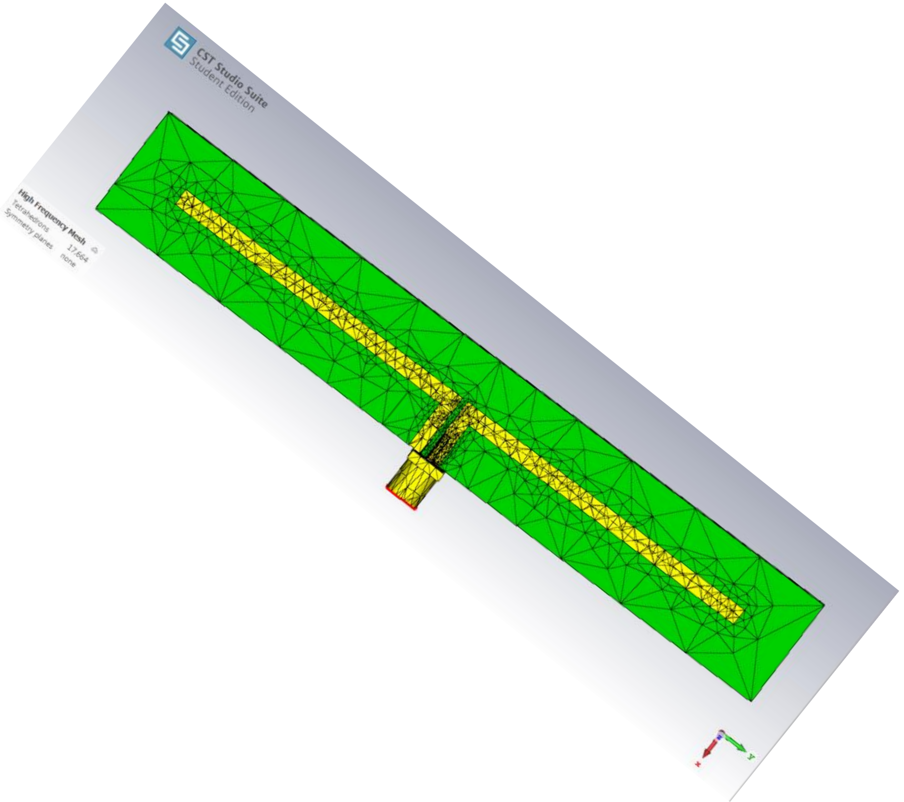


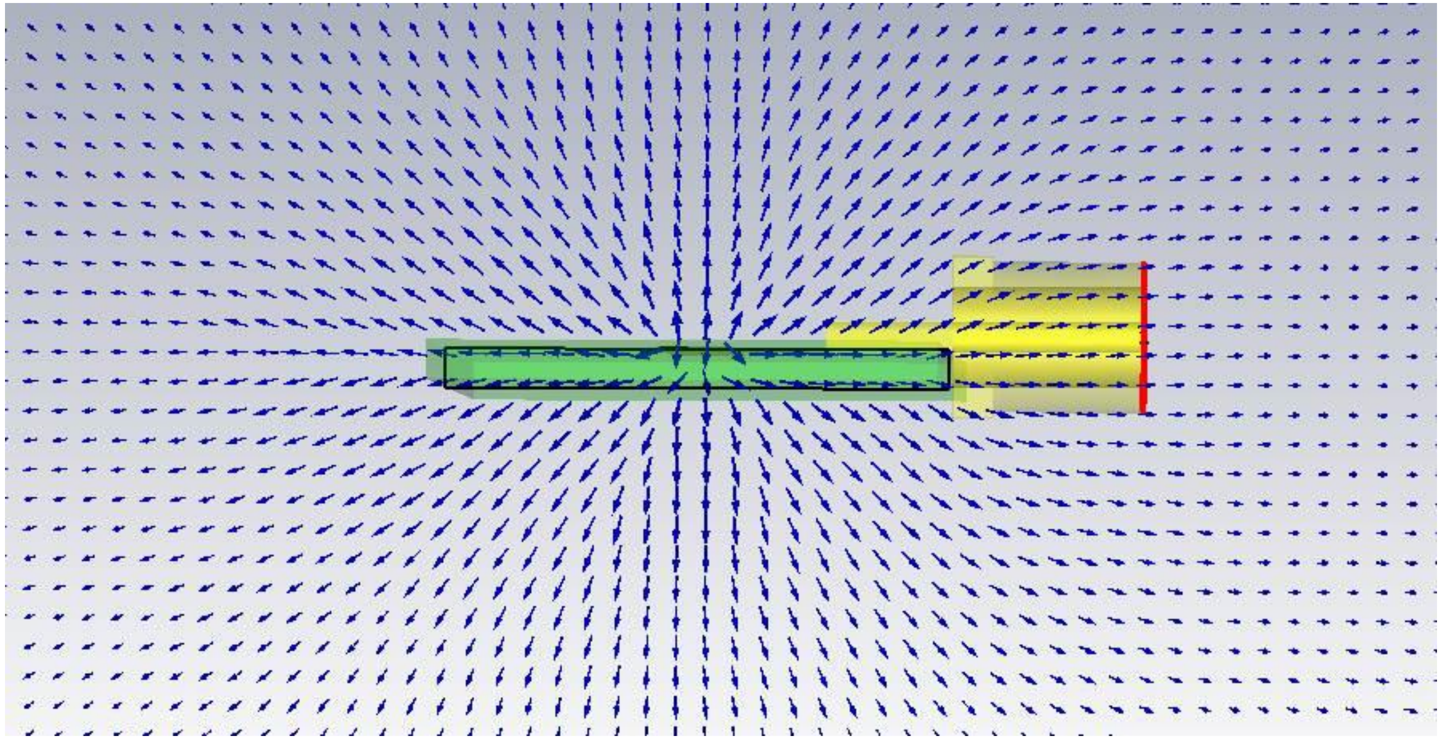

Cross-section TL mode



$$\lambda = \frac{c_0}{f\sqrt{\varepsilon_{r,eff}}}$$

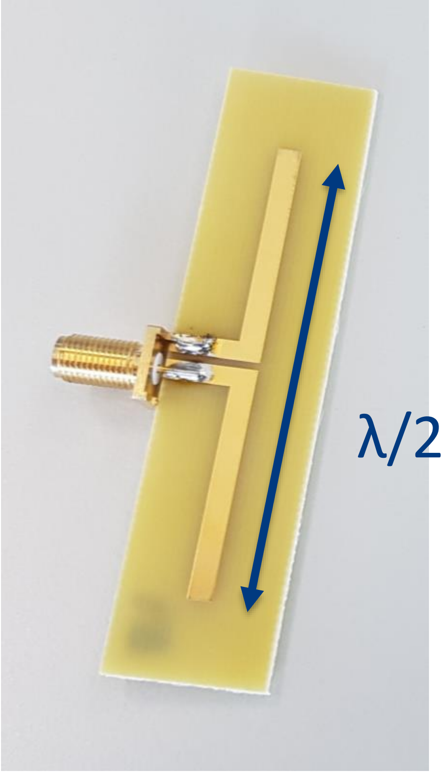
# E-Field Dipole Antenna



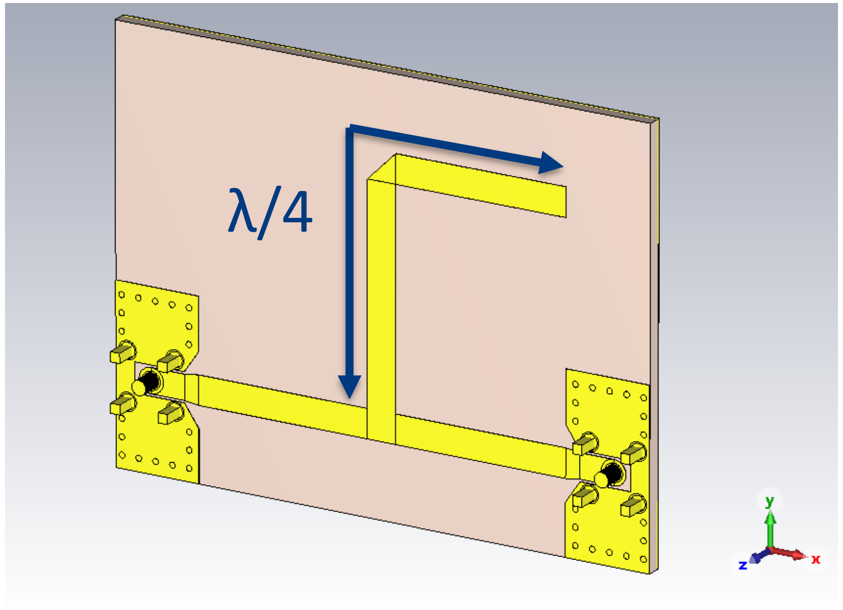
# Choice of λ / $\varepsilon_{r,eff}$?

## Fields are not confined




$\varepsilon_{r,eff}$ can be extracted from CST

## Fields are confined




Substrate height h = 1.55 mm, relative permittivity $\varepsilon_{r,sub} = 4.3$ taken from PCB material FR4. $\varepsilon_{r,eff}$ can be calculated analytically: $\varepsilon_{r,eff} = \frac{\varepsilon_{r,sub}+1}{2} + \frac{\varepsilon_{r,sub}-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{W}}}\right)$.

# Educated guess of effective relative permittivity

**<u>For both the dipole and the stub</u>**

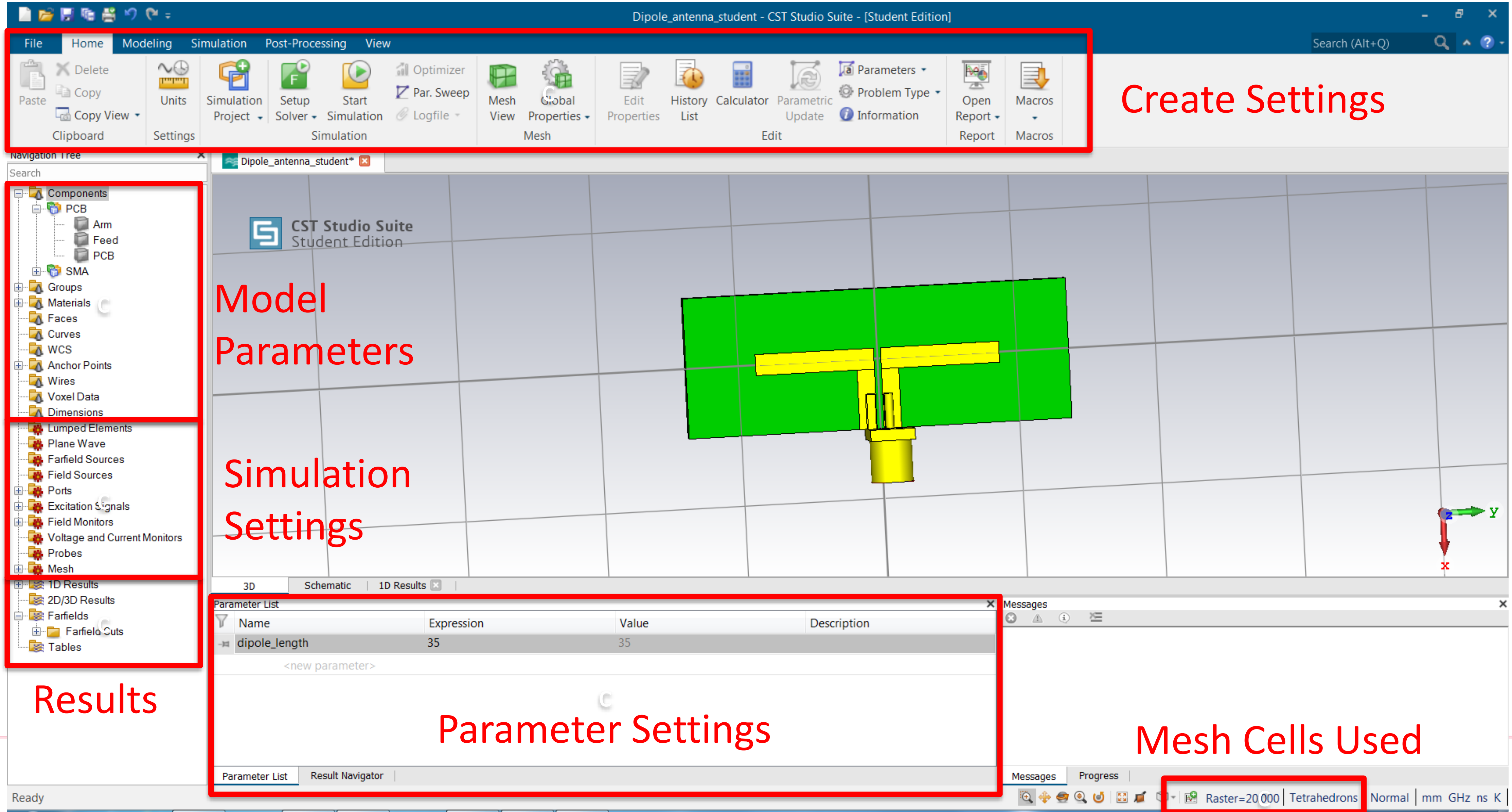
Reason yourselves

- What is the lower bound of $\varepsilon_{r,eff}$?
- What is the upper bound of $\varepsilon_{r,eff}$?
- Which medium is mostly surrounding the conductors?

# Topics

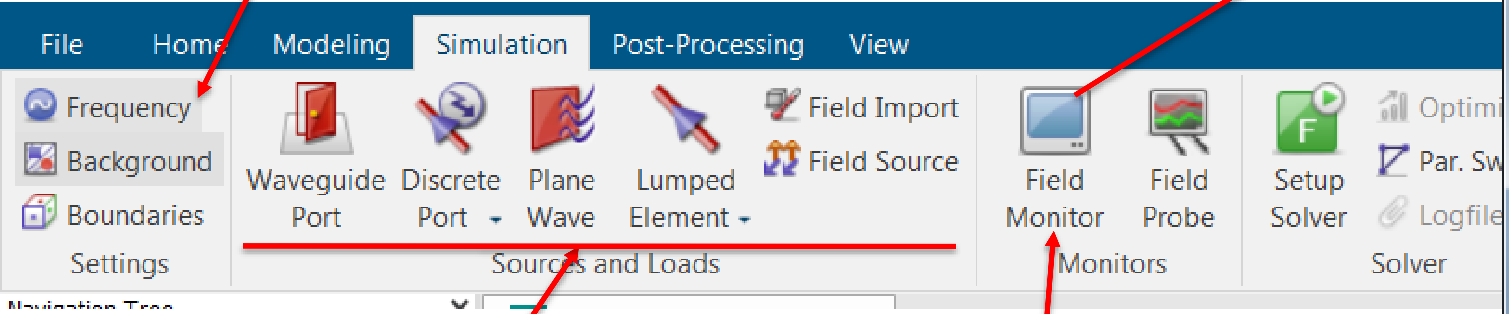
- How do antenna modeling tools work?
- Relative permittivity
- **CST**
- Simulating your antenna

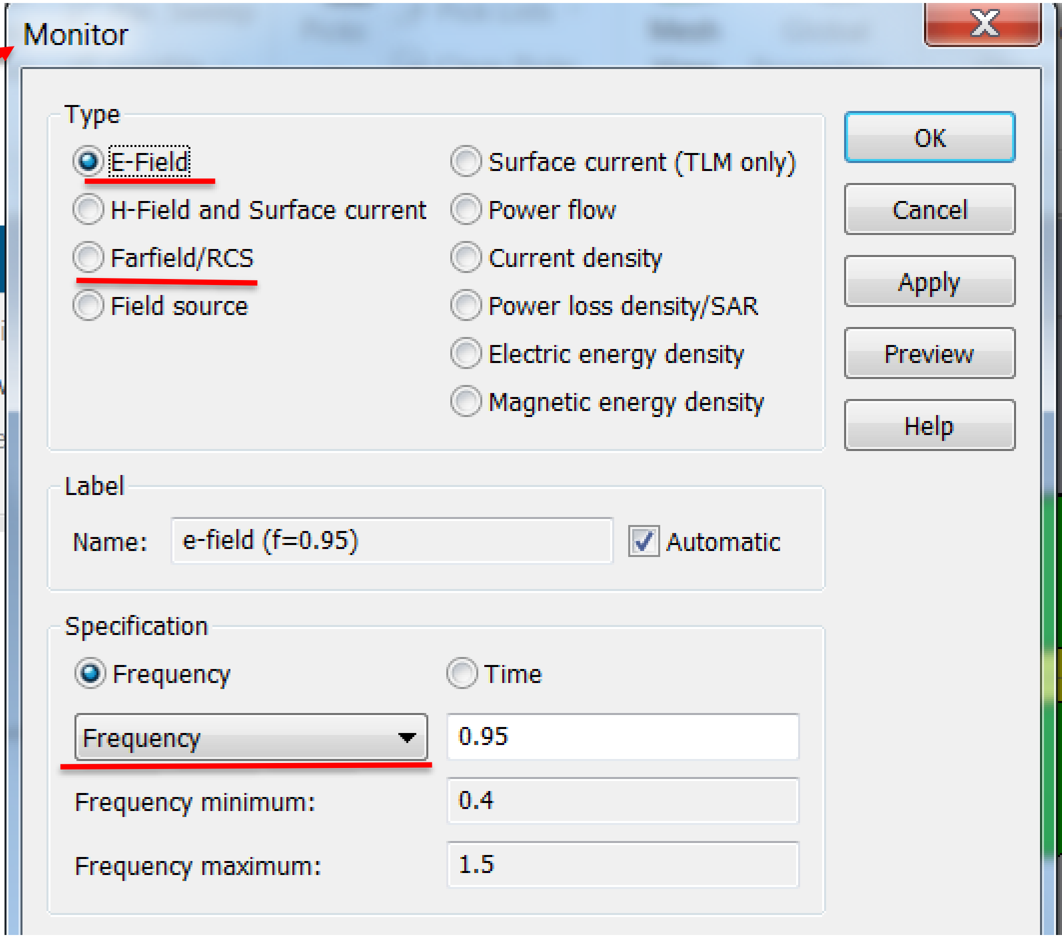
# CST


Dipole_antenna_student - CST Studio Suite - [Student Edition]
File Home Modeling Simulation Post-Processing View
Paste Delete Copy Copy View Clipboard
Units Settings
Simulation Project Setup Solver Start Simulation Optimizer Par. Sweep Logfile Simulation
Mesh View Global Properties Mesh
Edit Properties History List Calculator Parametric Update Parameters Problem Type Information Edit
Open Report Report
Macros Macros
Create Settings
Navigation Tree
Components PCB Arm Feed PCB SMA Groups Materials Faces Curves WCS Anchor Points Wires Voxel Data Dimensions
Model Parameters
Lumped Elements Plane Wave Farfield Sources Field Sources Ports Excitation Signals Field Monitors Voltage and Current Monitors Probes Mesh
Simulation Settings
1D Results 2D/3D Results Farfields Farfield Cuts Tables
Results
CST Studio Suite Student Edition
3D Schematic 1D Results
Parameter List
Name Expression Value Description
dipole_length 35 35
<new parameter>
Parameter Settings
Parameter List Result Navigator
Messages Progress
Mesh Cells Used
Ready
Raster=20 000 Tetrahedrons Normal mm GHz ns K

# CST

Set simulation frequency range

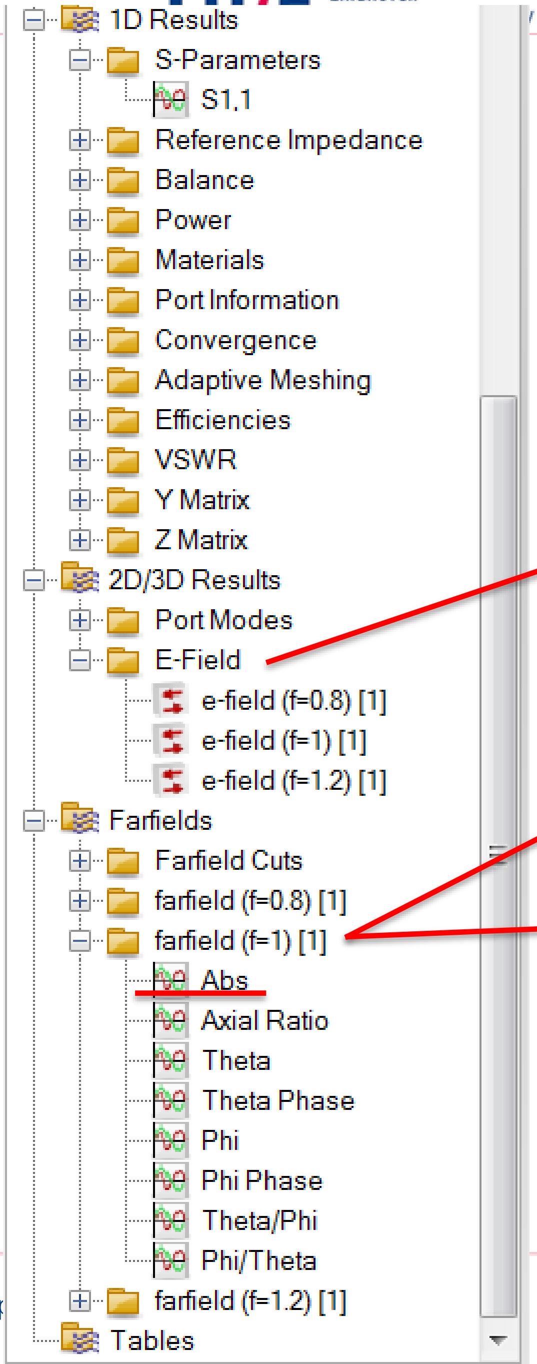


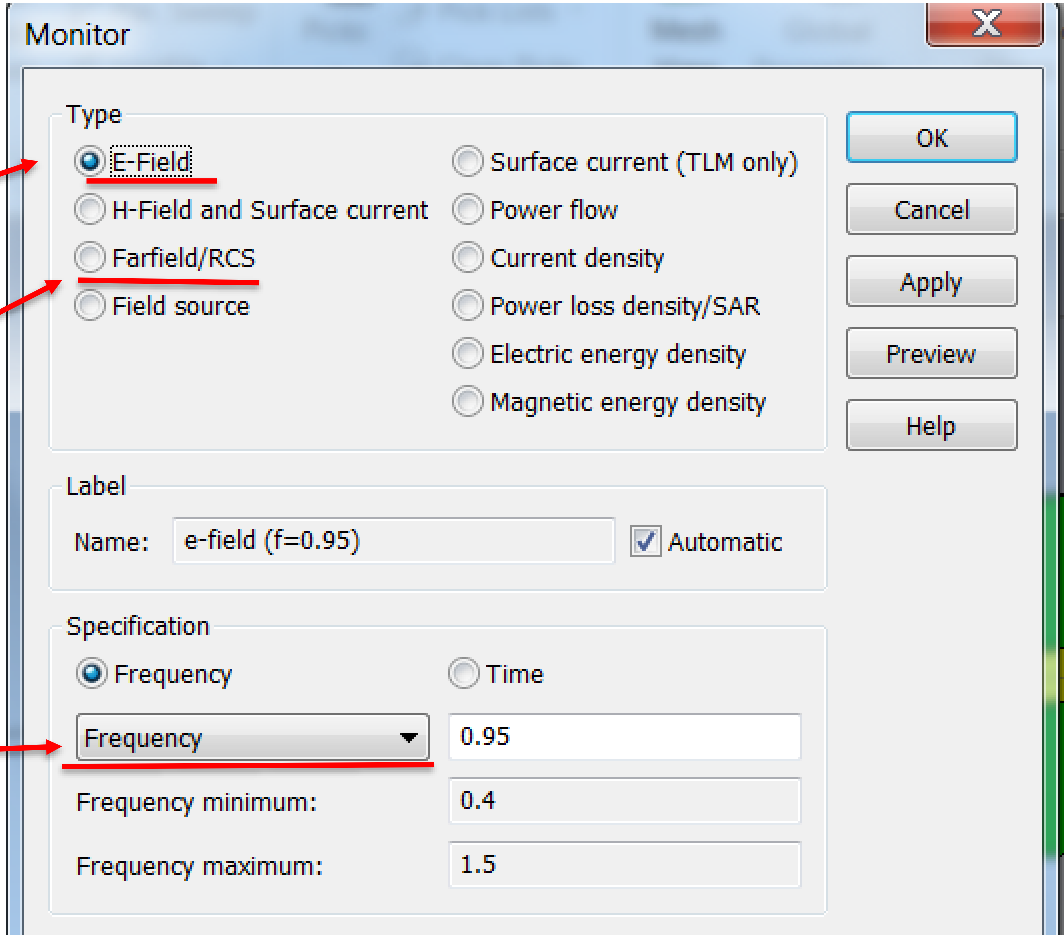




Set type of excitation port (Already done in your model)

Set which effects you would like to monitor

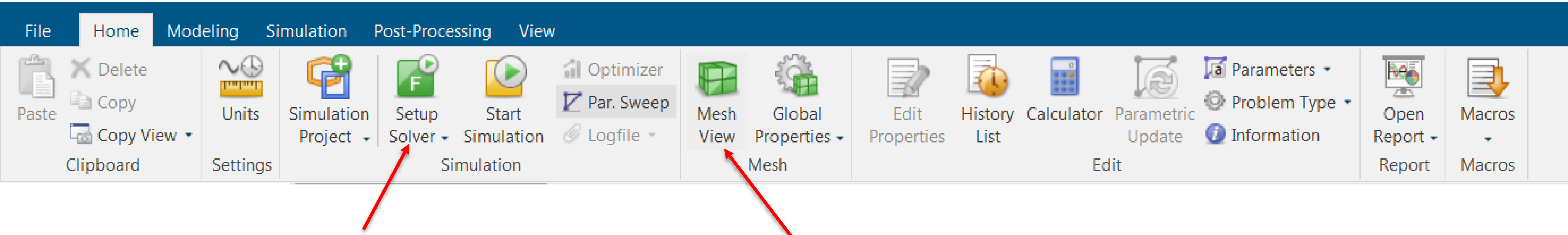
# CST


1D Results
S-Parameters
S1,1
Reference Impedance
Balance
Power
Materials
Port Information
Convergence
Adaptive Meshing
Efficiencies
VSWR
Y Matrix
Z Matrix
2D/3D Results
Port Modes
E-Field
e-field (f=0.8) [1]
e-field (f=1) [1]
e-field (f=1.2) [1]
Farfields
Farfield Cuts
farfield (f=0.8) [1]
farfield (f=1) [1]
Abs
Axial Ratio
Theta
Theta Phase
Phi
Phi Phase
Theta/Phi
Phi/Theta
farfield (f=1.2) [1]
Tables


Monitor
Type
E-Field
H-Field and Surface current
Farfield/RCS
Field source
Surface current (TLM only)
Power flow
Current density
Power loss density/SAR
Electric energy density
Magnetic energy density
OK
Cancel
Apply
Preview
Help
Label
Name:
e-field (f=0.95)
Automatic
Specification
Frequency
Time
Frequency
0.95
Frequency minimum:
0.4
Frequency maximum:
1.5

# CST

The student version only allows for using 20.000 mesh cells, you have to take this into account when simulating!




What solver do you want to use?
Frequency domain -> Narrowband
Time domain -> Broadband

Visualize the mesh cells

# CST

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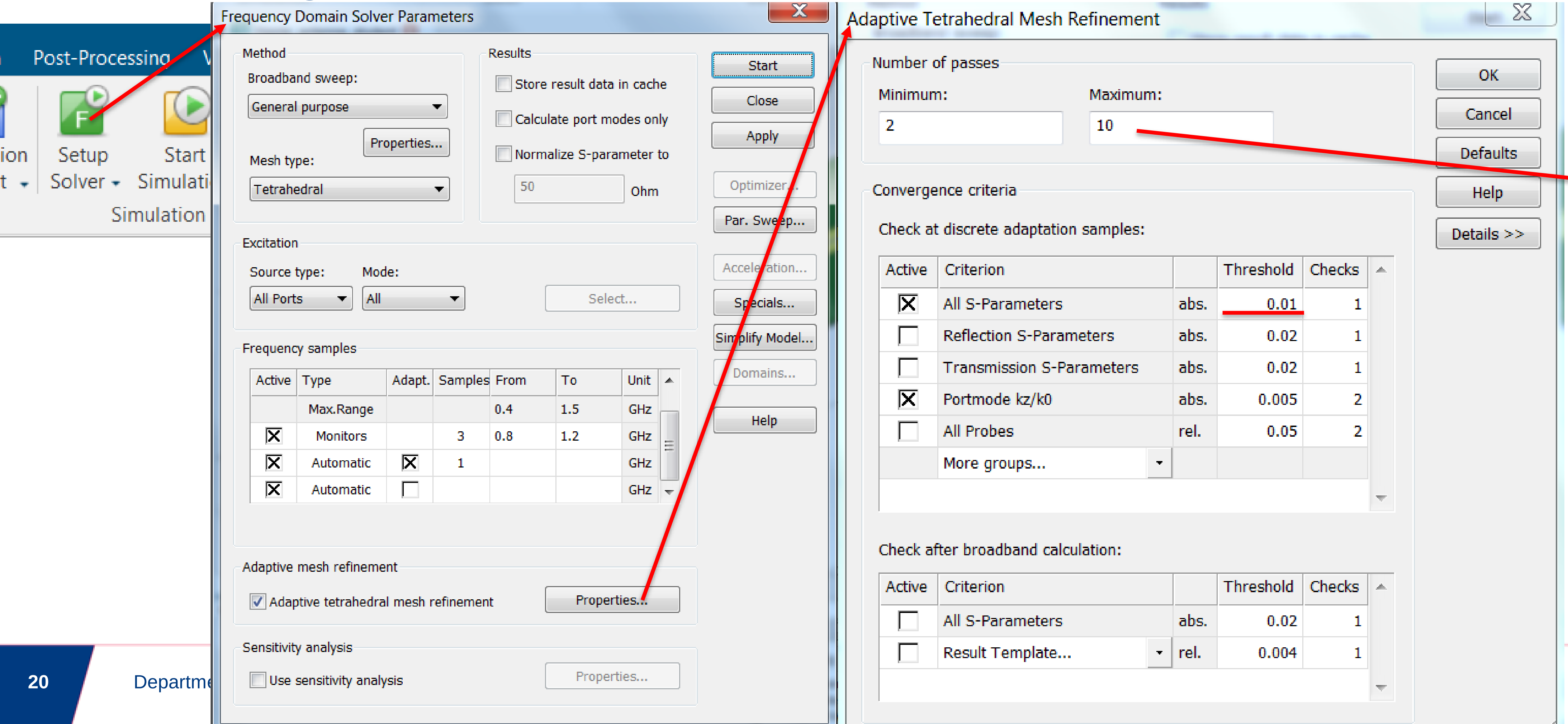
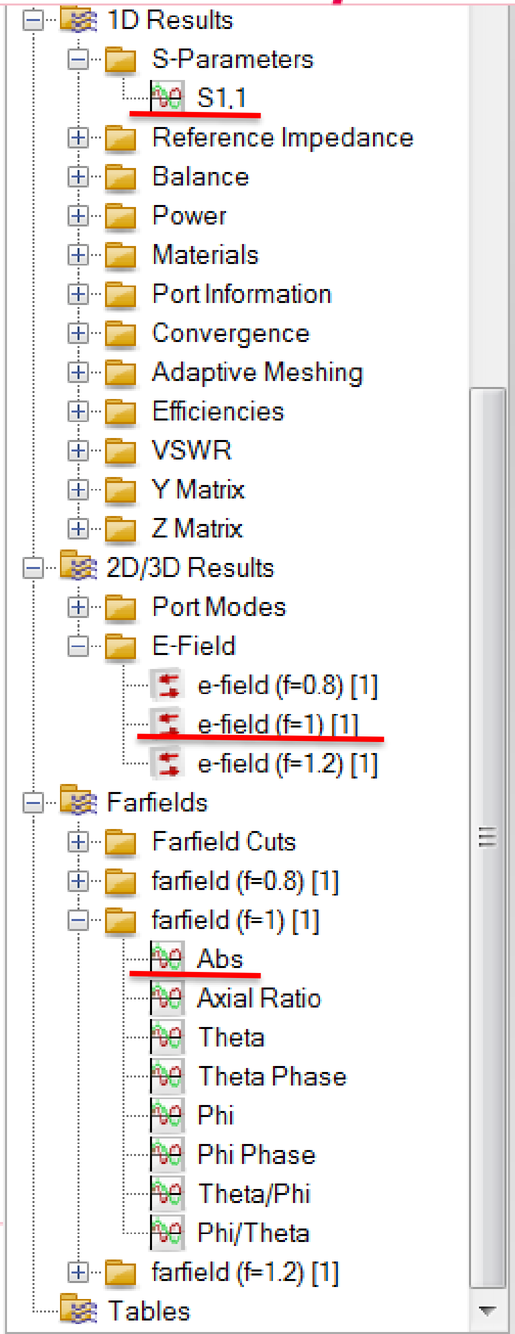



Adjust yourself

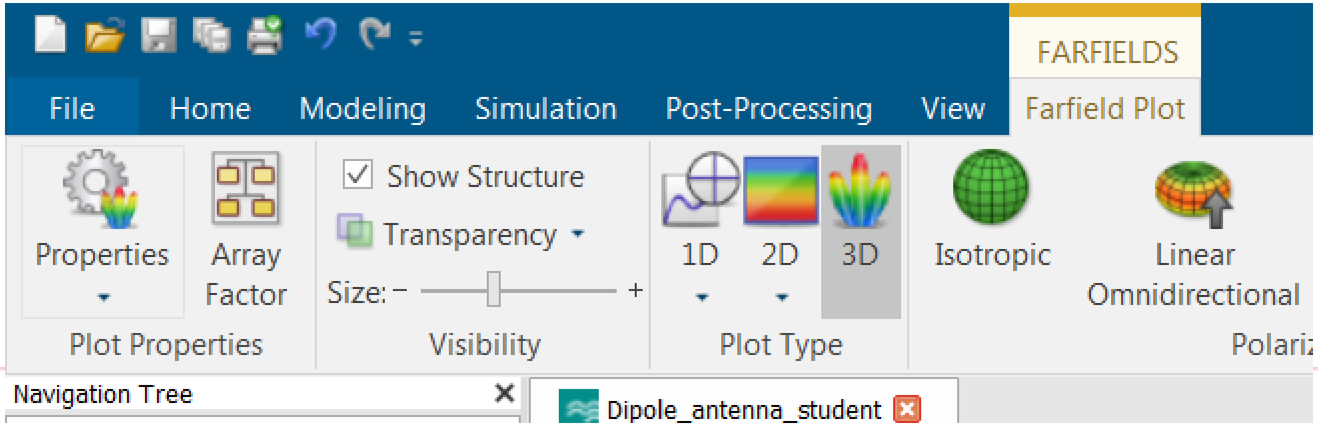



# CST

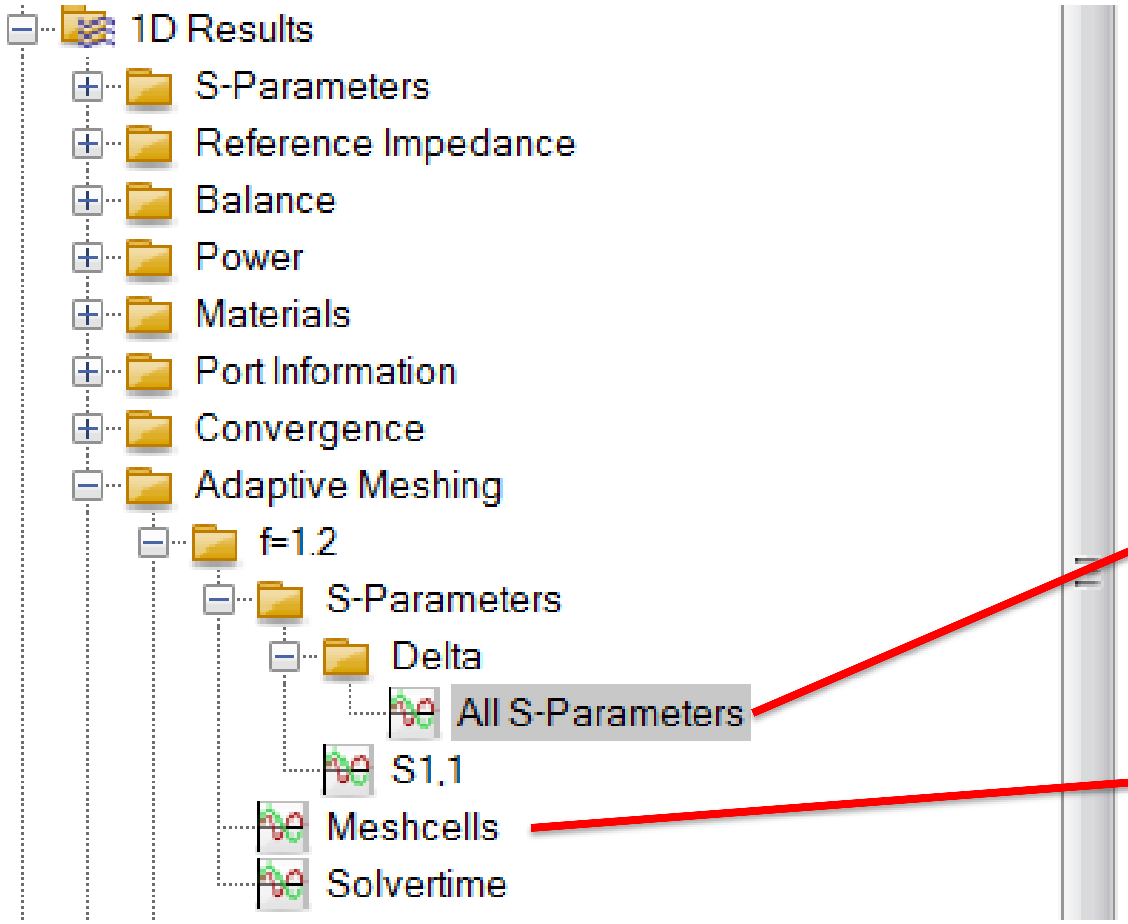
Important to check:

- S11
- Radiation pattern (Farfield Abs)
- E-Field direction

When you click on a result, an extra tab occurs where you can set how you would like to see your results, try it out!



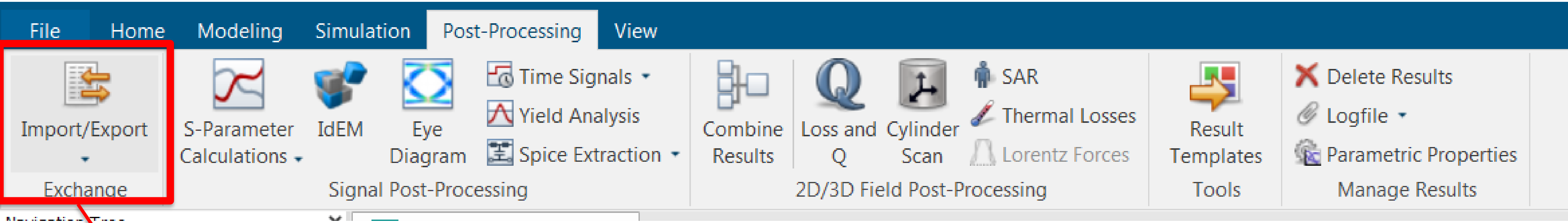
# CST




Check if adaptive meshing threshold is met

Check number of mesh cells

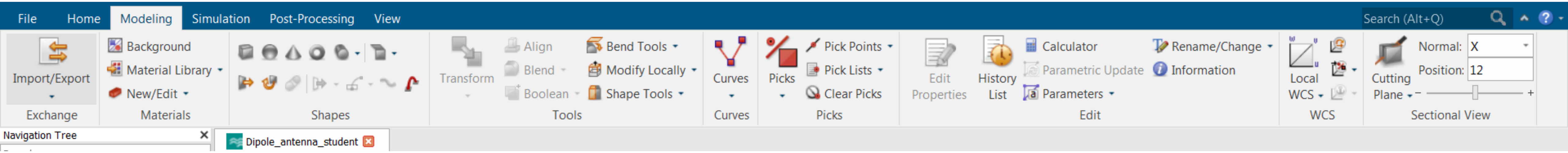
# CST




Export data to
Touchstone (.s2p file)

# CST

The modeling tab can be used to draw various shapes. This is outside of the scope of this course, but a separate slideshow on this is uploaded in the Canvas folder of Lab 3 if you are interested!



# Topics

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- **Simulating your antenna**

# Simulating your antenna

- Antenna (save your data and plot it in Matlab!)
  - Calculate the correct dipole length for a resonance at 1 GHz and simulate
  - $S_{11}$ should have a minimum (< -10 dB) around your design frequency, is this the case? If not, why and how far off is your simulation from your desired value? Try to optimize until you have the correct value.
  - Check the radiation pattern. Is this what you would expect from a dipole? Why?
  - What about the gain? It that would you theoretically would expect?
  - Is the radiation pattern symmetric? Why (not)?
  - What is the polarization of this antenna (linear/circular)? Why?
- CST
  - How did you verify that you used enough mesh cells?
  - Where do the least/most mesh cells occur after iterative meshing? Why?